It should be noted that these corrections for filters apply only when the quartz-mercury arc is the light source. If the carbon arc is used, a correction for the infrared transmission of the glass would also have to be made, since the Meter response is partially due to infrared.

Correction for Type of Quartz-Mercury Arc Lamp

The nature of the electrodes used in the quartz-mercury arc, whether liquid mercury or solid metal (or both), does not affect the calibration of the Meter sufficiently to justify correction. The Meter with its calibration may be employed for either type of quartz-mercury arc.

Accuracy of Calibration

The Hanovia Ultraviolet Meter, employed as described and with the proper calibration factors and multipliers, can measure the ultraviolet energy in the region of therapeutic ultraviolet 3200 to 1850 Angstroms with an accuracy of:

+ or — 5%........Quartz-Mercury Arc
+ or — 10%........Carbon Arcs (A, B, C)
+ or — 15%........Quartz High-voltage Mercury Discharge.

Permanency of Calibration

The user can expect the sensitivity of the Meter to decrease gradually with usage. Deterioration of the cell is very slow, and with ordinary use will not appreciably affect the calibration until after several years of service. Frequent and lengthy exposures to very intense light sources and overheating will hasten the deterioration.

If the Meter is used frequently, it is recommended that the calibration be checked about once a year.

Effect of Temperature

The response of the Meter is not materially affected by temperatures ranging from 80 degrees to 160 degrees Fahrenheit.

When the Meter is employed under conditions which result in the cell in the Target being lower than 80 degrees Fahrenheit (27 degrees Centigrade), it is necessary to allow for the decrease in response due to temperature. The sensitivity of the Meter decreases as the temperature decreases. The temperature corrections are given in the following table:

HANOVIA ULTRAVIOLET METER

Foreword

The Hanovia Ultraviolet Meter is designed for the measurement of the intensity of the therapeutic ultraviolet in the spectral region 3200 to 1850 Angstroms emitted by the Quartz-Mercury Arc, "A", "B", and "C" Carbon Arcs, and the Quartz High-Voltage Mercury Discharge. The employment of the calibration factor which is to be found on the meter itself and the correction multipliers which are given in these instructions will enable the user to evaluate the ultraviolet intensity in absolute energy units and to correlate the measured intensity with exposure time for erythema production.

Description of Meter

The Hanovia Ultraviolet Meter is a photronic device manufactured by the Weston Electrical Instrument Company in a design developed by the Hanovia Research Laboratory. The Meter consists of two parts: the Target, which receives the ultraviolet from the lamp and converts it into electrical energy; and the Indicating Instrument, which measures the electrical energy generated. Each complete Meter is tested and calibrated by the Hanovia Research Laboratory.

The Target employs the Weston Photronic Cell shielded from visible light by a filter glass which transmits the ultraviolet and some infrared radiations. It is connected to the Indicating Instrument by means of a flexible electric cord five feet in length.

The Indicating Instrument is an accurate Weston Microammeter, which is provided with a special scale divided into hundredths and which has multipliers to give the instrument sufficient range of measurement. The microammeter is permanently mounted in a quartered grain oak meter box, 8½ x 4¼ x 8¾ inches, provided with a cover and a leather handle. Provision is made within the meter box for the Target, electric cord, and the instruction book. The entire instrument weighs 7½ lbs.

Method of Operation

The Hanovia Ultraviolet Meter is completely self-contained; that is, it requires *no* electric batteries, *no* radio tubes, *no* attachment to an electric current supply for operation.

The meter is ready for use at any time.

Before a measurement is made, it is important to ascertain that the filter glass on the Target is clean and free from dust. Obviously, if this glass be dirty, less light energy can pass thru, and a light measurement which is too low in value would result. A gentle breathing upon the glass and polishing with a soft cloth is usually sufficient. *Under no circumstances* should the Target be demounted in order to clean the glass on the inside.

The Target is placed at the distance from the lamp and in the position at which the light intensity measurement is to be made. It is preferable that it be laid on a table, or a cot, or the floor rather than that it be held in the hand, since unsteadiness resulting from the latter gives rather uncertain results.

It is IMPORTANT, when the Hanovia Ultraviolet Meter is employed for measuring lamps that produce high light intensities and *much heat*, that the Target be exposed to the light only long enough to make the measurement. Short exposures of several minutes duration to high light intensities will not damage the photronic cell in the Target, but prolonged exposures will permanently damage the cell.

When comparing the intensity of two or more lamps it is well to remember that reflectors produce "hot points" and that, for a true comparison, a number of points under each lamp should be measured.

When the filter window of the Target is exposed to the light from the quartz-mercury arc lamp at the distance from the lamp and at the location at which the light intensity measurement is desired, the switch mounted upon the Indicating Instrument should be turned to the position marked "LOW."

The pointer of the Indicating Instrument will immediately register the light intensity. The meter scale should be read to the nearest integer. Each scale mark indicates an even number, such as 2, 4, 6, 8, 10, etc. If the pointer comes to rest between two marks, an odd number should be read. Thus, if the pointer rests between 8 and 10, the reading is 9.

If the light intensity should be so great that the pointer passes off the scale, it is necessary to employ a multiplier. This is done by moving the switch mounted on the Indicating Meter to the position marked "MEDIUM". The position of the pointer is then noted in the usual way, the meter scale being read to the nearest integer. The reading obtained is then multiplied by five (5) to obtain the real value for the light measurement. (Example: With the switch at "MEDIUM," the pointer resting between 34 and 36 on the scale, the correct reading is $35 \times 5 = 175$.)

If the light intensity is very high, especially if the measurement is being made very close to a burner, it will be necessary to move the switch to the position marked "HIGH." The reading is then made in the ordinary way and multiplied by twenty (20) to obtain the real value for the light measurement. (Example: With the switch at "HIGH," the pointer resting at 32 on the scale, the reading is $32 \times 20 = 640$.)

Interpretation of Meter Scale Readings

The response of the Hanovia Ultraviolet Meter is directly proportional to the intensity of the light from the source. This means that the doubling of the light intensity multiplies the scale reading by two. Thus, if the Target be placed under a lamp in such a position that the pointer indicates 40, and if it then be moved nearer to the lamp until a reading of 80 is indicated, the intensity of the light energy in this second position would be just twice that in the first.

The numbers on the Meter Scale are purely arbitrary. If another Hanovia Ultraviolet Meter were taken, and the above measurements were repeated, maintaining all conditions of lamp intensity and distance the same, the second meter might read 64 and 128, or any other pair of numbers, the one being twice the other.

If a Hanovia Meter should be employed for the comparison of the ultraviolet from the quartz-mercury arc, a carbon arc, and the sun, readings such as 220, 430, and 780 might be obtained, although actually the ultraviolet intensities of these three sources might be in the reverse order, the mercury arc being the most intense. The absolutely erroneous impression resulting from such measurements is caused by the nature of the spectral response of the photronic cell within the Target. The cell responds to the infrared rays which are transmitted by the ultraviolet filter. The sun and the carbon arc emit much more infrared than the mercury arc.

The preceding illustration indicates the necessity of having an ultraviolet meter calibrated for the light source with which it is to be used, and in energy terms that are reproducible.

The Hanovia Ultraviolet Meter may be calibrated for any light source that maintains a constant spectral-energy distribution. A light source is considered to maintain a constant spectral energy distribution when the proportions of short ultraviolet, long ultraviolet, visible, short infrared, and long infrared remain practically without change during the life of the light source. Sunlight does not maintain a con-

stant distribution and ***the Hanovia Ultraviolet Meter in its present form cannot be employed for the determination of the ultraviolet of sunlight.***

The Hanovia Ultraviolet Meter is calibrated for the shorter therapeutic ultraviolet, 3200 Angstroms to 1850 Angstroms in wavelength. The cell in the Target responds also to the longer ultraviolet (3200 to 4000 Angstroms) and also to the shorter wavelengths of the infrared (heat radiations). The reading obtained when the Target is exposed to the light from the quartz-mercury arc results in part from the action of each of these three components, the short ultraviolet, the long ultraviolet, and the short infrared. Experience with a large number of quartz-mercury arc burners indicates that the energy ratio between these three components remains reasonably constant during the life of the quartz-mercury arc burner. The reading on the scale of the meter multiplied by the calibration factor which is stamped on the metal disc mounted upon the Target, gives a very true evaluation of the short ultraviolet from the quartz-mercury arc lamp.

The calibration factor converts the meter scale readings into MICROWATTS per SQUARE CENTIMETER PER SECOND. The calibration applies only to the short ultraviolet from quartz-mercury arcs that have a liquid cathode and mercury or tungsten anodes. When the meter is employed for the measurement of mercury glow discharge tubes, and carbon arcs, the calibration factor which is stamped upon the Target must be multiplied by a suitable factor. These factors will be found in subsequent paragraphs.

Whereas meter scale readings taken with different meters or on different light sources are NOT comparable, after conversion into microwatts per square centimeter per second the readings may be directly compared. The MICROWATT is one millionth of a watt (0.000,001). A MICROWATT per SQUARE CENTIMETER per SECOND of light energy is the quantity of light energy falling upon a square centimeter of area in each second, which, when converted into electrical energy, is equivalent to a microwatt.

Light energy can also be expressed as ERG SECONDS per SQUARE CENTIMETER per SECOND, or GRAM-CALORIES per MINUTE per SQUARE CENTIMETER, or GRAM-CENTIMETERS per SECOND per SQUARE CENTIMETER per SECOND. These energy units are related as follows:

1 microwatt per cm^2 per sec. = 10 erg seconds per cm^2 per second = 0.000,014,34 gram-calories per minute per cm^2 = 0.0102 gram-centimeters per second per cm^2 per second. (Note: If the areas are

expressed in millimeters, instead of centimeters, each of the above would be divided by 100, for 1 $cm^2 = 100$ mm^2.)

The following example illustrates the use of the calibration factor. The intensity of a quartz mercury arc lamp at 30 inches is to be determined. The intensity of the light is such that the switch on the meter box has been moved to the "MEDIUM" position. The reading on the scale is 49. The true reading is therefore $49 \times 5 = 245$ scale divisions. The calibration factor stamped upon the Target plate is 5.8; therefore, the intensity is $245 \times 5.8 = 1421$ microwatts per square centimeter per second for the shorter therapeutic ultraviolet, 3200 Angstroms to 1850 Angstroms.

Calibration Factor for Carbon Arcs ("A", "B", "C")

Relatively, the carbon arcs generate more infrared and long ultraviolet radiations that pass thru the filter of the Target and affect the photronic cell, than do the mercury arcs. It results from this that the Hanovia Ultraviolet Meter gives much larger readings for carbon arcs than for quartz-mercury arcs that have equivalent amounts of short ultraviolet. The ratios of this increased reading of the carbon arc to the mercury arc are constant. Hence, it is possible to apply a multiplying factor to the mercury-arc calibration of the Hanovia Meter, which permits the approximate evaluation of "A", "B", and "C" carbon arcs in *microwatts per square centimeter* per second for the ultraviolet *3200 Angstroms to 1850 Angstroms.*

"A" CARBON: multiply factor on Target by 0.12
"B" CARBON: multiply factor on Target by 0.34
"C" CARBON: multiply factor on Target by 0.37

Calibration Factor for Quartz High-Voltage Mercury Discharges

These tubes produce about 85 per cent. of their total radiation in the wavelength at 2536 Angstroms. The Hanovia Ultraviolet Meter is not very sensitive to this wavelength, with the result that the reading is always too small. The mercury-arc calibration factor on the Target, multiplied by 10, gives the calibration factor for the Cold High Voltage Discharge in the spectral region 3200 Angstroms to 1850 Angstroms.

NOTE: High Frequency Electrodeless Quartz-Mercury Discharge

The distribution of radiation spectral energy of this lamp varies with bulb diameter and power input. The Hanovia Ultraviolet Meter cannot be used for the evaluation of its short ultraviolet.

Calibration for TOTAL Ultraviolet Intensity from Quartz-Mercury Arc (Spectral Region 4000 A to 1850 A.)

The calibration factor on Target is multiplied by 1.80.

Erythema Production

Interpretation of microwatts per sq. cm. per second in terms of erythema time.

INTENSITY Microwatts/cm²/sec 3200 A—1850 A (Quartz-Mercury Arc & "B" & "C" Carbon Arcs)	EXPOSURE TIME Usual Time Limits for Exposure to result in First Degree Erythema (Mild blush, vanishing after 24 hrs)
10	1½ hours to 2½ hours
20	1 hour to 1½ hours
30	30 minutes to 1 hour
40	20 minutes to 30 minutes
50	16 minutes to 20 minutes
60	13 minutes to 16 minutes
75	11 minutes to 13 minutes
100	9 minutes to 11 minutes
150	7 minutes to 9 minutes
200	6 minutes to 7 minutes
400	4 minutes to 6 minutes
600	2 minutes to 4 minutes
800	1 minute to 2 minutes
1000	40 seconds to 1 minute
1500	20 seconds to 40 seconds
2000	10 seconds to 20 seconds
5000	5 seconds to 10 seconds
10,000	1 second to 5 seconds

NOTE: The approximate erythema production time for the Quartz High-Voltage Mercury Lamp may be obtained for any intensity by halving the erythema times given in the above table.

NOTE: Time limits are necessary because of the variation in skin sensitivity and response of different individuals. All times are for untanned areas.

Accuracy of the Hanovia Ultraviolet Meter

Correction for REFLECTORS

The employment of reflectors composed of aluminum, chromium, rhodium, and chrome-steel does not affect the accuracy of the Meter. No corrections are required when reflectors of these materials are used with the lamps for which the meter is calibrated.

Correction for FILTERS

Filters of pure water contained within vessels provided with windows of plane ground and polished transparent fused quartz do not affect the accuracy of the Meter and no correction need be applied to the calibration. The pure water may be replaced by a solution of sodium chloride without effect. (It should be noted that a filter such as the above will reduce the light intensity transmitted by about 14%, the light loss being due to reflection from the quartz walls.)

Solutions of colored inorganic salts, organic compounds, dyestuffs and drugs may have an appreciable effect on the value of the calibration factor. Special corrections must be determined and applied when these are used.

Ordinary window glasses do not transmit the therapeutic ultraviolet. A reading taken thru such a glass results from the action of the long ultraviolet and infrared, and has no significance.

Clear Corex D Glass (4 millimeters thickness) is at times employed for the elimination of therapeutic ultraviolet radiations which are not present in summer sunlight, but which are produced by artificial light sources. Readings with the Meter made thru this glass filter are about 15 per cent. too high. The reason for this condition is given under "Carbon Arcs," page 7. When a Corex D filter is used on the quartz-mercury arc, the light intensity measurement is made in the usual manner. The Corex D filter correction is made by multiplying by 0.85. A measurement such as this will give the intensity of the lamp thru Corex D for the spectral region 2800 to 3200 Angstroms.

Red Purple Corex Glass (Corning G986A) is employed at times with lamps because of its ability to transmit the ultraviolet while excluding most of the visible radiations. This filter has a better transmission in the longer ultraviolet than in the shorter. Hence, it gives a reading with the Meter that is too high. When the quartz-mercury arc is the light source this amounts to 17 per cent. The Red Purple Corex correction is made by multiplying by 0.83.

It should be noted that these corrections for filters apply only when the quartz-mercury arc is the light source. If the carbon arc is used, a correction for the infrared transmission of the glass would also have to be made, since the Meter response is partially due to infrared.

Correction for Type of Quartz-Mercury Arc Lamp

The nature of the electrodes used in the quartz-mercury arc, whether liquid mercury or solid metal (or both), does not affect the calibration of the Meter sufficiently to justify correction. The Meter with its calibration may be employed for either type of quartz-mercury arc.

Accuracy of Calibration

The Hanovia Ultraviolet Meter, employed as described and with the proper calibration factors and multipliers, can measure the ultraviolet energy in the region of therapeutic ultraviolet 3200 to 1850 Angstroms with an accuracy of:

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The user can expect the sensitivity of the Meter to decrease gradually with usage. Deterioration of the cell is very slow, and with ordinary use will not appreciably affect the calibration until after several years of service. Frequent and lengthy exposures to very intense light sources and overheating will hasten the deterioration.

If the Meter is used frequently, it is recommended that the calibration be checked about once a year.

Effect of Temperature

The response of the Meter is not materially affected by temperatures ranging from 80 degrees to 160 degrees Fahrenheit.

When the Meter is employed under conditions which result in the cell in the Target being lower than 80 degrees Fahrenheit (27 degrees Centigrade), it is necessary to allow for the decrease in response due to temperature. The sensitivity of the Meter decreases as the temperature decreases. The temperature corrections are given in the following table:

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